SmartRay

SmartRay™ ECCO 35 / ECCO 55 Series

User Manual

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Legal notice

Impressum

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Original User Manual

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1 About this user manual

1.1 General

Target group

This user manual is intended to help system integrators working in the field of 3D machine vision in the setup, installation and operation of SmartRay ECCO 35 and ECCO 55 3D sensors. The information in this user manual enables users or employees with the relevant experience to mount and operate the sensor.

Important note

The safe mounting, installation and commissioning of the sensor assumes knowledge of this user manual. It is essential, therefore, to read through this user manual – and the safety and warning instructions in particular – before beginning work.

1.2 Symbols and signal words

The following symbols and signal words are used in this user manual.

Safety instructions/Warnings

Safety instructions consist of the following five elements:

- Danger symbols
- Signal word
- Description of the danger
- Possible consequences
- Measures for avoidance

	SIGNAL WORD **Description of the danger.** Possible consequences. ● Measures for avoidance.

Safety symbol	Signal word	Meaning
	DANGER	This signal word is used to indicate an **imminently dangerous situation** that will result in serious or fatal injury **if not avoided**.
	WARNING	This signal word is used to indicate a **potentially dangerous situation** that could result in serious or fatal injury **if not avoided**.

Safety symbol	Signal word	Meaning
	CAUTION	This signal word is used to indicate a potentially dangerous situation that could result in minor or moderate injury if not avoided.
	ATTENTION	This signal word **without a warning symbol** is used to indicate potential danger of damage to property.
	NOTE	This signal word indicates additional useful information for the reader, such as operating tips or cross-references.

Other symbols for further information

	Important information that must be observed to avoid problems with the sensor.
	Further information that simplifies your work with the SmartRay sensor is marked with this symbol.
	Cross-references to other documents are marked with this symbol.

1.3 Abbreviations

Abbreviation	Description
2D/3D	2-dimensional/3-dimensional
API	Application Programming Interface
BG	German employer's liability insurance association
BGR	German employer's liability insurance association rules
CW	Continuous Wave
DIN	German Industrial Standards
EMC	Electromagnetic Compatibility
EN	European Norm
ESD	Electrostatic Discharge
FOV	Field of View
GND	Ground
IEC	International Electrotechnical Commission
IO	Input/Output
ISO	International Organization for Standardization
LED	Light Emitting Diode
MR	Measurement Range
PIL	3D-Profile, Intensity, LaserLineThickness
RMA	Return Material Authorization
SDK	Software Development Kit
SO	Stand-off Distance
SR	SmartRay
VDE	German Association for Electrical, Electronic & Information Technologies
ZIL	Z-Map, $Intensity_{Z\text{-}Map}$, $LaserLineThickness_{Z\text{-}Map}$

2 Safety

2.1 Intended use

Fields of application

The SmartRay ECCO 3D sensor is designed for use in the industrial image processing sector.

It can be used for:

- Quality inspection
- Metrology
- Robot guidance
- Reverse engineering

The SmartRay ECCO 3D sensor may only be operated within the values specified in the technical data. See the *Description, page 15* section.

Non-intended use

Any other use or use beyond that intended is deemed to be non-intended use. In the event of modification or reconstructions, operational safety is no longer ensured.

Safe operation

For the correct, safe and professional use of the SmartRay ECCO 3D sensor, it is essential to be familiar with and to heed the respective corresponding safety regulations and information.

NOTICE

- Therefore, before commissioning your SmartRay sensor, carefully read through the separate *SmartRay – General laser safety* information and the Safety chapter of this user manual.
- It is essential to heed to warnings and information listed here.

2.2 Device-specific safety instructions

WARNING

Danger of injury from improper handling of the sensor.

Non-compliance with these instructions can cause injury.

- The operating company using the ECCO 3D sensor is responsible to ensure a safe implementation of the sensor into the designed application. This includes necessary protective devices and instructed personnel.
- Only operate the sensor in a flawless, properly functioning state.
- Ensure that the sensor is regularly checked for proper functioning.
- Maintenance work and troubleshooting must be carried out by trained, authorized qualified personnel.
- Unauthorized constructional modifications can have an adverse effect on safety.

2.3 Warning against laser beams

Safety review

WARNING

Danger of injury from laser beams.

The laser comply with class 2M.

Laser power 15 mW

Wavelength of 660 nm

Looking directly into the beam for a time period of more than 0.25 s or repeatedly looking into the laser beam of class 2M laser products can lead to eye injuries.

- Observe the laser safety regulations (see information in document *SmartRay – General laser safety*)!

Obligations of the operating company

For safety reasons, the operating company of the 3D laser system has important duties to ensure safety during operation. In particular, the following applies:

- Cordoning-off of the laser area.
- Clear marking of the laser area.
- Operation of the laser with the minimum required power.
- Carrying out of work on the laser measurement system only by specially trained personnel.
- Checking of the laser protection safety measures by a laser safety officer.

NOTICE

In addition to the information given on the topic of laser safety in this user manual, also heed the separate information in the *SmartRay – General laser safety* and the Laser safety chapter.

Laser safety

The tight bundling of the laser beam means the entire energy of the radiation is concentrated on a small cross-section. If a person is hit by the beam, this can cause damage to health. Depending on the wavelength of the laser, the beam can reach the retina and damage it.

According to the potential hazard, lasers or devices that contain a laser are divided into classes in accordance with EN 60 825 "Safety of laser products".

The SmartRay ECCO 3D sensor belongs to class 2M.

NOTICE

- The laser class of the sensor can be found on the label of the sensor.
- The laser classes listed in the following comply with the standard DIN EN 60825-1 (VDE 0837-1):2008-05 - October 2007 release.

Due to the tight bundling and the associated high power density of the laser beams, the beams in more powerful laser products can be damaging to health. This also applies to reflections on glass surfaces and metallic or polished surfaces.

Laser classes

Laser class 2M

The available laser radiation of laser products of class 2M lies in the visible spectral range (400 nm to 700 nm).

In laser products of class 2M, there is a comparable hazard to laser products of class 2 provided no optical instruments (e.g. magnifying glass or microscope) are used that reduce the beam cross-section.

CAUTION

Danger of injury from laser beams.

Looking directly into the beam for a time period of more than 0.25 s or repeatedly looking into the laser beam of class 2M laser products can lead to eye injuries.

- If laser radiation of class 2M hits the eyes, consciously close your eyes and immediately turn away.

Laser class 3B

The available laser radiation lies in the wavelength range of 302.5 nm to 10^6 nm and is dangerous to the eyes, frequently also to the skin.

WARNING

Danger of injury from laser beams.

Looking directly into the beam in laser products of class 3B is dangerous!

- Observe the laser safety regulations.
- When working on the sensor, wear the laser protection glasses provided for this purpose.

Laser-specific regulations

Labeling of the laser classes (laser warning labels)

According to section 5.8 DIN EN 60825-1, laser products of classes 2 to 4 must be identified on a label by data about the maximum initial values of the laser radiation, the emitted wavelength and (if applicable) the pulse duration.

Example of the labeling of a laser:

Laser class 2M	Laser class 3B

Measures for laser class 3B

According to DIN EN 60825-1, a system with a laser of class 3B must fulfill the following:

- All directives of the preceding laser classes (technical expertise, labeling, access restrictions among other things) apply
- Nomination of a laser safety officer
- An installed signal lamp must indicate the operating status of the laser

- Remote-controlled locking system
- Key switch
- Beam attenuator
- Eye protection (if constructive and organizational measures are not practicable)

WARNING

Danger of injury from improper handling.

Non-compliance with these instructions can cause injury.

- Do not use reflective tools during adjustment work and do not wear any reflective objects (e.g. jewelry).
- Where applicable, national directives and measures that are not listed here must be fulfilled.

2.4 ESD protection

ATTENTION

Because the sensor is a sensitive electronic part, it can be destroyed by improper handling.

- Only carry out assembly in accordance with the applicable ESD protective measures.

Manufacture and checking by SmartRay

The sensors are manufactured and checked on the SmartRay premises under stringent ESD protective measures (according to IEC 61340-5-1). These protective measures are already demanded from and complied with by our suppliers. The sensors are sent in ESD-conform packaging. This protects the contents from electrostatic charges.

Recommendations for handling the sensors

Recommendation for ESD handling:

- Ground the service personnel and work area during assembly and/or repair work.
- Avoid contact with the connector contacts.

ATTENTION

Because the sensor is a sensitive electronic part, it can be destroyed by improper handling.

- Keep the original packaging so you can use it for sending the sensor back for repair if necessary (ESD protection).

3 ECCO 35 / ECCO 55 at a glance

3.1 Overview

This section describes how the sensor is constructed, the typical fields of application and the working principle.

System components

A functioning sensor system consists of the following components:

- SmartRay ECCO 3D sensor
- Power-I/O cable
- Ethernet cable
- Encoder cable (optional)
- StarterKit Software with a "Getting Started" installation guide (PDF)
- USB stick with calibration file (Look-up table, *.lut)

Sensor series

The following types of models of the ECCO 35 and ECCO 55 sensor series are available:

- ECCO 35 Series
  - ECCO 35.050
  - ECCO 35.100

- ECCO 55 Series
  - ECCO 55.020
  - ECCO 55.050
  - ECCO 55.100

3.2 Working principle

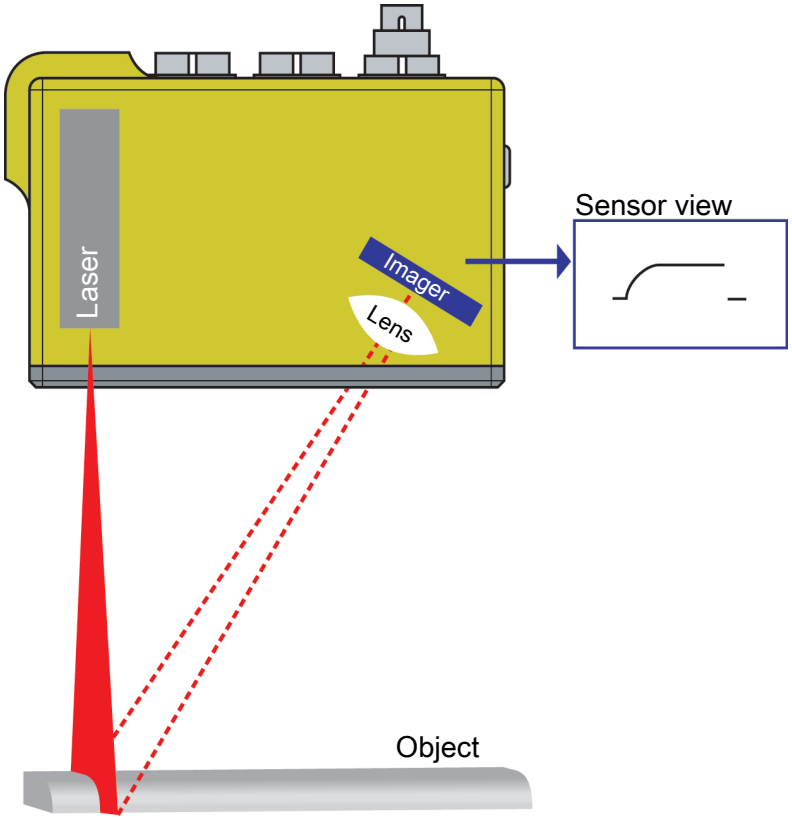
Function

SmartRay 3D sensors measure distances based on the laser triangulation principle.

The 3D sensor projects a laser line onto the object which is reflected back onto an image sensor. Due to the triangulation angle between the laser line, object and the image sensor, the reflected laser line appears at different positions on the image sensor depending on different distances to the measured object. In other words, the 3D sensor measures the profile of the object, and scanning the object renders a 3D-model of the object!

The calibration methods developed by SmartRay allow for measurements in the micrometer range!

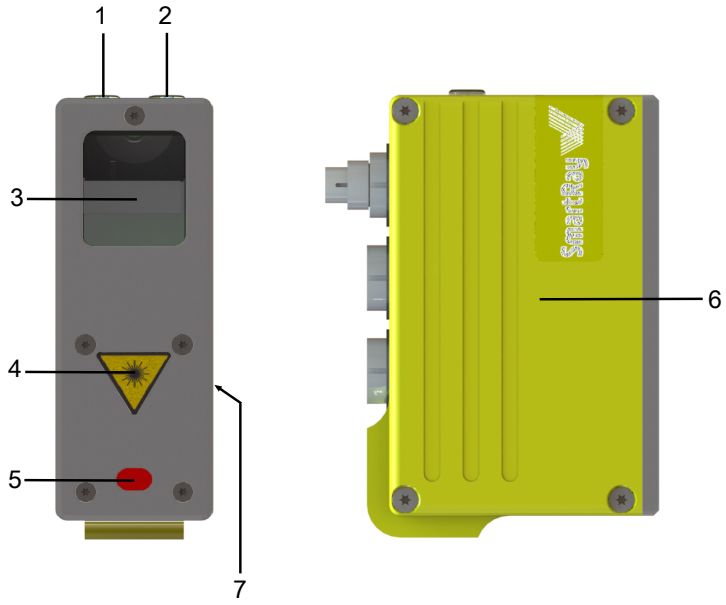
Schematic diagram of laser triangulation



3.3 Description

Sensor views (front | side)

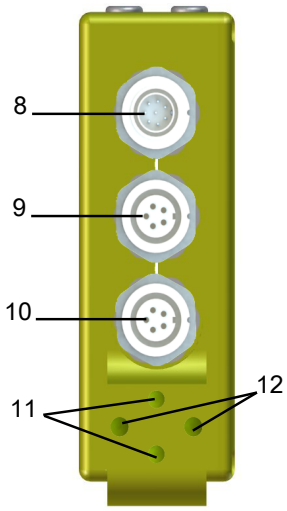
The following figures show the sensor from the front and side:



1 Alive LED – L1
2 Status LED – L2
3 Camera front glass
4 Laser warning label
5 Laser output
6 Housing
7 Nameplate

Sensor view (rear)

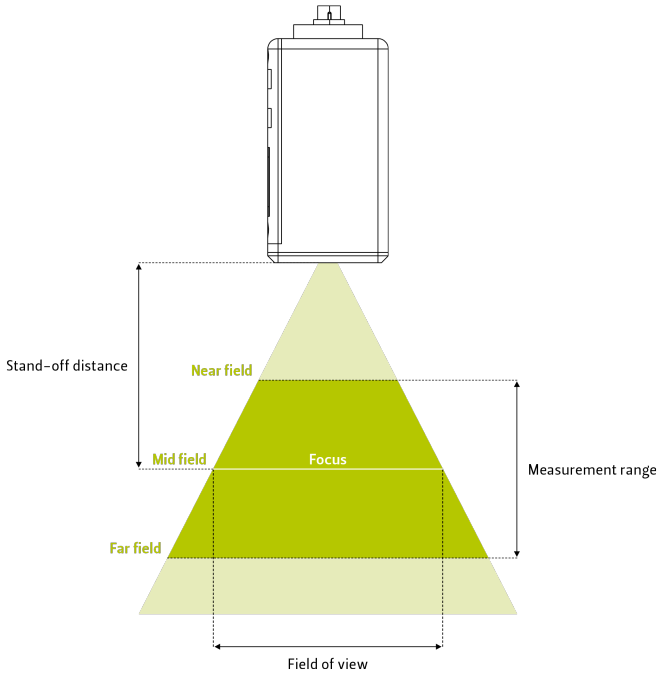
The following figure shows the sensor from the rear with its electrical connectors:



8	Power-I/O connector (8-pin male)
9	Ethernet connector (8-pin female)
10	Encoder connector (5-pin female)
11	Borings for dowel pin (3m6)
12	Threaded holes for M4 screws

Technical data

Sensor specification



Technical data ECCO 35 Series

Model	ECCO 35.050	ECCO 35.100
Maximum scan rate [KHz]	0.5	
Measurement range [mm]	60	100
Field of view [mm] (near | **mid** | far)	41 | **49** | 57	61 | **82** | 103
Stand-off distance [mm]	150	
Typical lateral resolution [µm]	57 – 80	82 – 135
Typical vertical resolution [µm]	8.5 – 16.5	11.5 – 32.5
Maximum points / 3D-profile	752	
Interface	Fast Ethernet (100 Mbit/sec)	
Inputs	4 x Inputs, 10 - 24 VDC | Quadrature Encoder (AB-Channel, RS-422 standard)	
Outputs	2 x Outputs, 24 VDC	
Input voltage | Power	24 VDC, ± 15 % ripple | 4.5 W	
Weight	180 g	
Laser wavelength	660 nm	
Laser class (standard | optional)	2M | -	
Maximum ambient light	10,000 lx	

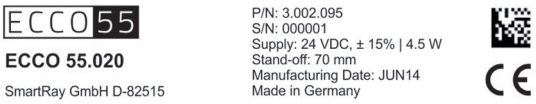
Model	ECCO 35.050	ECCO 35.100
EMC test	as per EN 61000-6-2, EN 61000-6-4	
Vibration / Shock test	as per EN 60068-2-6, -27, -29, -64	
Electrical safety	as per EN 61010-1-3	
Protection class	III, as per EN 61040-3	
Enclosure rating	IP65	
Air humidity	Maximum 90 %, non-condensing	
Temperature (operation | storage)	0 – 40 °C | -20 – 70 °C	

Technical Data ECCO 55 Series

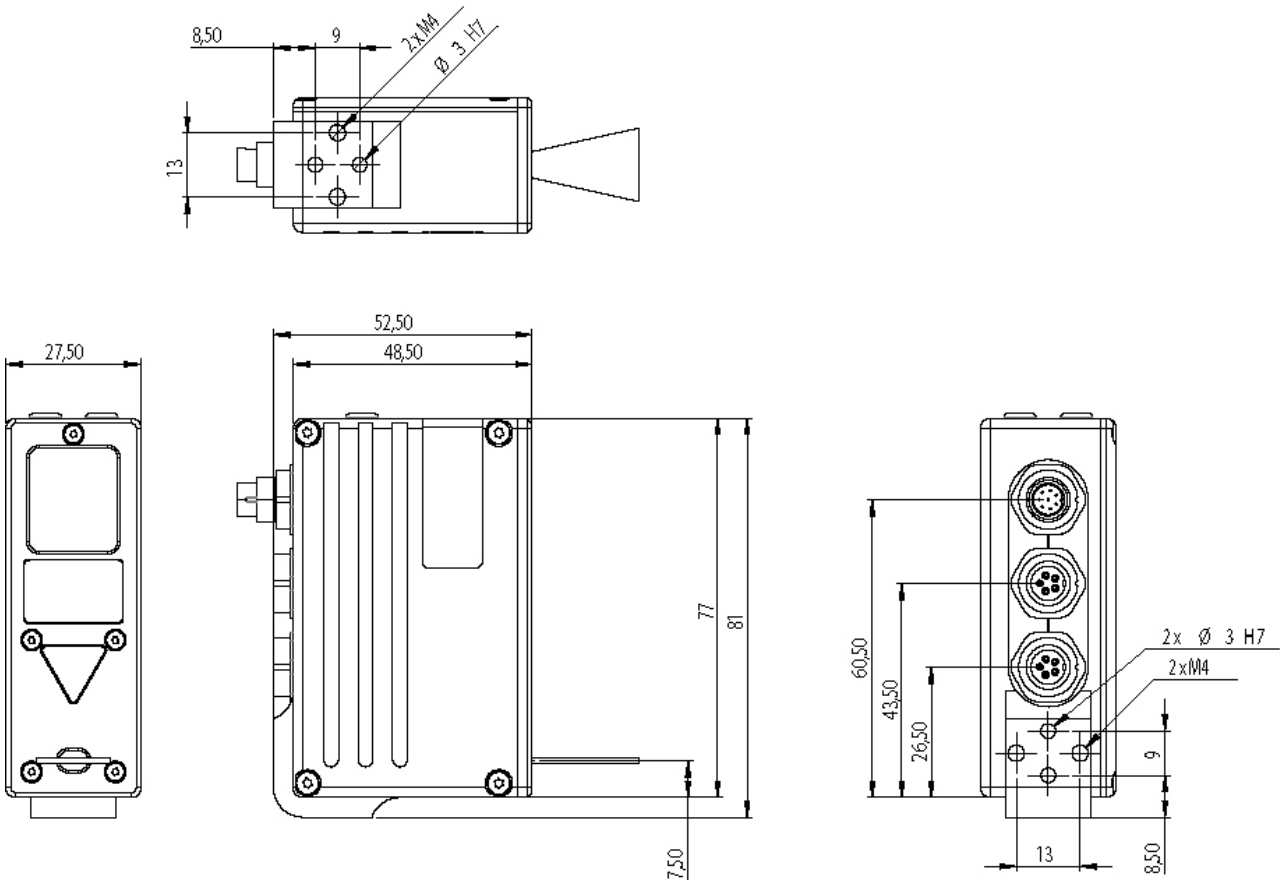
Model	ECOO 55.020	ECCO 55.050	ECCO 55.100
Maximum scan rate [KHz]	6		
Measurement range [mm]	20	60	100
Field of view [mm] (near | **mid** | far)	22 | **24** | 26	58 | **69** | 81	88 | **118** | 148
Stand-off distance [mm]	70	150	
Typical lateral resolution [µm]	35 - 40	85 – 115	136 – 228
Typical vertical resolution [µm]	3.25 – 4.75	13.5 – 27	19 – 53.5
Maximum points / 3D-profile	640		
Interface	Fast Ethernet (100 Mbit/sec)		
Inputs	4 x Inputs, 10 - 24 VDC | Quadrature Encoder (AB-Channel, RS-422 standard)		
Outputs	2 x Outputs, 24 VDC		
Input voltage | Power	24 VDC, ± 15 % ripple | 4.5 W		
Weight	180 g		
Laser wavelength	660 nm		
Laser class (standard | optional)	2M | -		
Maximum ambient light	10,000 lx		
EMC test	as per EN 61000-6-2, EN 61000-6-4		
Vibration / Shock test	as per EN 60068-2-6, -27, -29, -64		
Electrical safety	as per EN 61010-1-3		
Protection class	III, as per EN 61040-3		
Enclosure rating	IP65		
Air humidity	Maximum 90 %, non-condensing		
Temperature (operation | storage)	0 – 40 °C | -20 – 70 °C		

Nameplate

Example: Nameplate of the ECCO 55.020



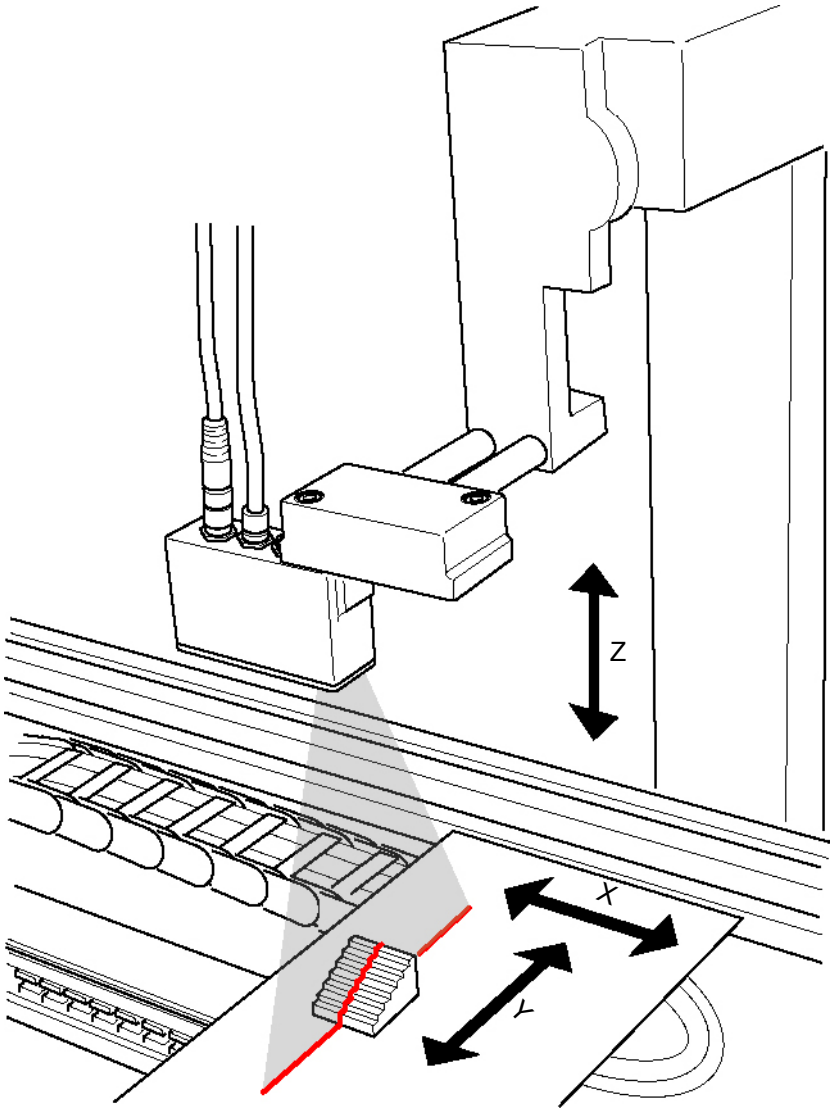
Dimensional drawing



3.4 Coordinate system

Definition of coordinates

The three axes in the coordinate system are defined as follows:



X Scan or transport direction
Y Along the laser line
Z Height or distance between the sensor and the object

3.5 Calibration

Sensor calibration

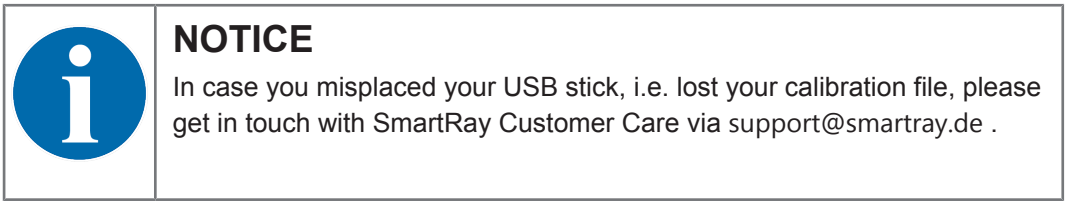
Highest accuracy of measurement is achievable thanks to a calibration procedure specially developed by SmartRay. Each sensor unit is individually calibrated with a variety of reference points within the field of view and measurement range. As a result, any kind of distortion and deviation is corrected, some of which are:

- Perspective distortion
- Lens distortion
- Laser non-linearity
- Manufacturing tolerances

Sensor-specific calibration data

The result of calibration is saved onto a "calibration file" which is shipped along with each sensor on a USB stick. The calibration file is basically a look-up table, often simply referred to as LUT and has a file extension '*.lut'.

The data from the sensor along with the combination with the calibration file gives the advantage of generating your data in real world coordinate dimensions, i.e. in millimeters.



NOTICE

In case you misplaced your USB stick, i.e. lost your calibration file, please get in touch with SmartRay Customer Care via support@smartray.de .

3.6 Order numbers

ECCO 35 Series

Model	Order number
ECCO 35.050	3.002.005
ECCO 35.100	3.002.010

ECCO 55 Series

Model	Order number
ECCO 55.020	3.002.095
ECCO 55.050	3.002.105
ECCO 55.100	3.002.110

Accessories

Designation	Order number
Power-I/O cable (Standard | 5 m)	6.310.005
Power-I/O cable (Standard | 10 m)	6.310.010
Ethernet cable (5 m)	6.302.005
Ethernet cable (10 m)	6.302.010
Encoder cable (2 m)	6.306.010

NOTICE

In regard to the subsequent use of accessories, please get in touch with your contact person at SmartRay.

4 Installation

4.1 Mounting the sensor

Preparation

Prepare an appropriate holder (e.g. on the robot, assembly line).

For hole pattern dimensions, see section *Description, page 15*.

Procedure

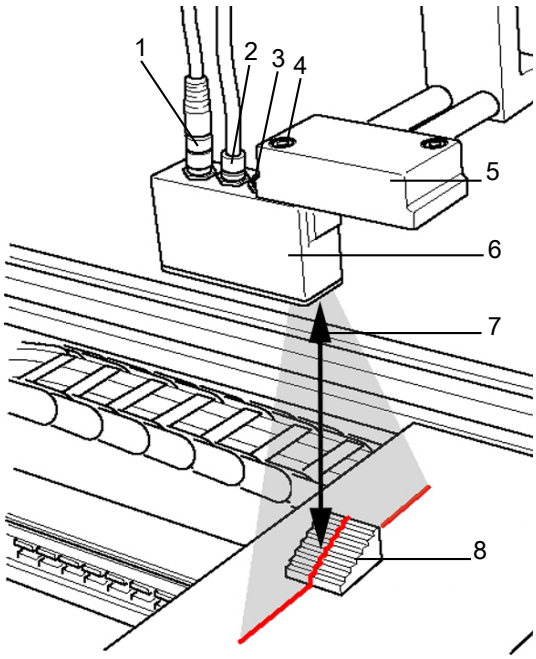
Proceed as follows in order to mount the sensor on the holder provided:

Step	Action
1	Unpack the sensor and cables. **ATTENTION** Keep the original packaging so you can use it to send the sensor back for repair if necessary (ESD protection).
2	Fix the sensor in place on the holder (fixing holes). Tightening torque: 4 Nm.

Sensor orientation

NOTICE

The sensor must be mounted to the object at a certain distance. This "Stand-off distance (mid)" is measured from the front of the sensor to the center of the object and can be looked up in the technical data of the sensor under "Field of view".

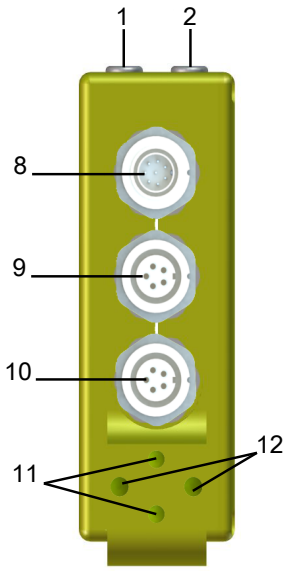


1 Power-I/O cable
2 Ethernet cable
3 Encoder connector (optional)
4 Mounting screw
5 Stand / Holder
6 3D sensor
7 Stand-off distance (mid)
8 Object

4.2 Connecting cables

Connections and displays

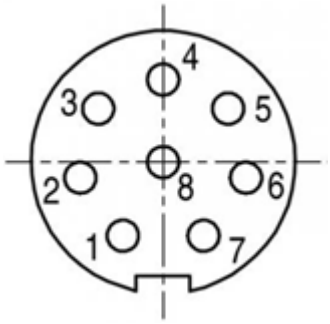
The following figure shows the sensor from the rear with its electrical connections and displays:



1	Alive LED – L1
2	Status LED – L2
8	Power-I/O connector
9	Ethernet connector
10	Encoder connector (optional)
11	Borings for dowel pin (3m6)
12	Threaded holes for M4 screws

Terminal assignment 8-pin power-I/O cable

Pin assignment



Description of cable wiring

Pin	Wire color	Brief designation	Meaning/Description
Pin 1	White	0 V (24 V return)	Operating voltage -
Pin 2	Brown	+24 V	Operating voltage +
Pin 3	Green	Output 0	24 V
Pin 4	Yellow	Output 1	24 V
Pin 5	Gray	Input 0	10 … 24 V
Pin 6	Pink	Input 1	10 … 24 V
Pin 7	Blue	Input 2	10 … 24 V
Pin 8	Red	Input 3	10 … 24 V

Description of the inputs and outputs

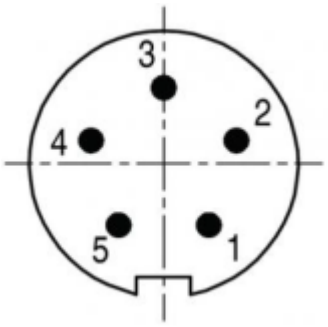
Pin	Brief designation	Meaning/Description
Pin 3	Output 0	Custom use via SmartRay API
Pin 4	Output 1	Custom use via SmartRay API
Pin 5	Input 0	Custom use (unused Inputs must be connected to GND) Switches the laser power ON/OFF: ● When powering up the device, the laser is activated briefly at the low level setting. ● The laser can be deactivated any time regardless of the input signal via software.
Pin 6	Input 1	Custom use (unused Inputs must be connected to GND)
Pin 7	Input 2	Custom use (unused Inputs must be connected to GND)
Pin 8	Input 3	Custom use (unused Inputs must be connected to GND)

Terminal assignment Encoder cable

Description

- SmartRay sensors can detect “AB-Channel” triggers generated from an external incremental encoder, which is conform to the RS-422 standard.
- The maximum (idle) voltage between A+/A- and B+/B- must not exceed 5 V.
- There is a terminating resistor of 120 Ω between A+/A- and B+/B-.
- For cable lengths over 2 meters, a twisted pair electrical connection should be used.
- The wiring colors are based on a standard 5-pin connector lead, as described below.

Pin assignment



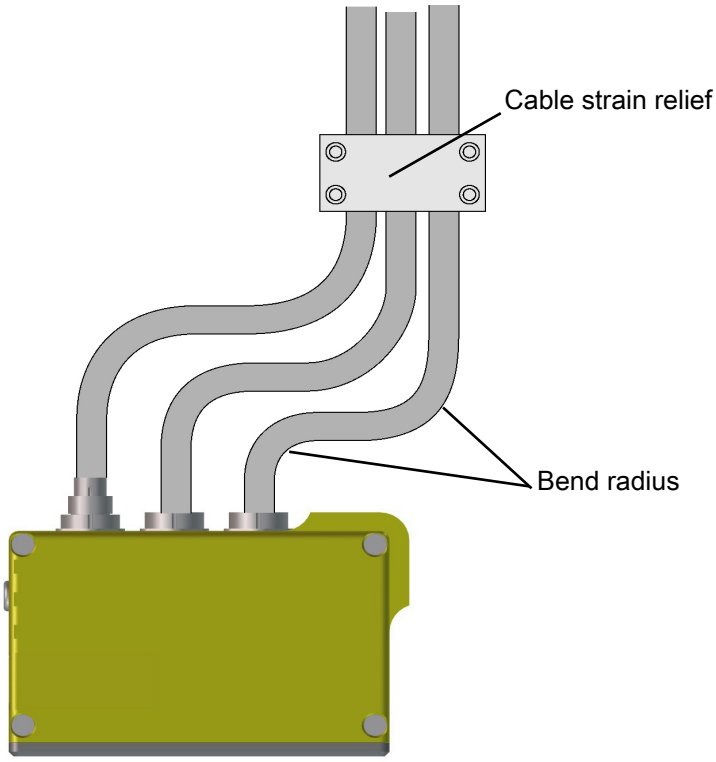
Description of cable wiring

Pin	Wire color	Brief designation	Meaning/Description
Pin 1	White	A+	Input A+
Pin 2	Brown	A-	Input A-
Pin 3	Green	B+	Input B+
Pin 4	Yellow	B-	Input B-
Pin 5	Gray	GND	100 kΩ connected to GND

Bending radius/Strain relief device of the cables

Schematic representation

The following image shows the strain relief device and bending radius of the cables:



Bending radius

	ATTENTION **Danger of damage to the cables.** Going below the minimum bending radius results in damage to the cables and can lead to faulty transfer of signals and data. Any damage leads to mandatory replacement of the cables. ● Adhere to the minimum admissible bending radius.

The typical bending radius to be used is shown in the following table:

Minimum bending radius (d = diameter)

Type	Formula	Minimum bending radius for SmartRay cables (d = 7.8 mm)
Fixed	5 x d	39.5 mm
Freely moving	10 x d	79.0 mm
Constantly moving	12 x d	94.8 mm

Strain relief device

If the cables are constantly in motion (operating on the robot/an axis), it is important to ensure that a strain relief device which does not allow transverse and tractive forces on the connector and socket of the sensor is mounted.

	ATTENTION **Danger of damage to the cables.** A missing strain relief device will result in damage to the cables and can lead to the faulty transfer of signals and data. Any damage leads to mandatory replacement of the cables. ● Mount a strain relief device if the cables are permanently moving.

4.3 StarterKit Software

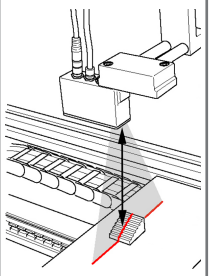
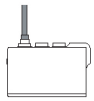
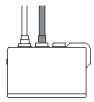
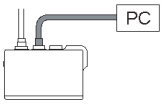
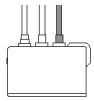
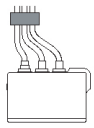
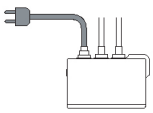
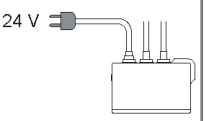
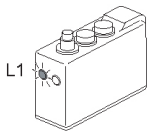
The StarterKit Software is part of the sensor delivery. The software has to be installed on the host computer to be able to configure and communicate with the sensor.

	For installation of the StarterKit Software see SmartRay document *Getting Started*. This installation guide is part of the sensor delivery (PDF).

4.4 Step-by-step installation

Connecting the sensor and establishing readiness for operation

Proceed as follows in order to connect the sensor and to establish readiness for operation:

Step	Action	Schematic
1	Check that the sensor maintains the correct "stand-off distance" between sensor and object. **NOTE** It is recommended to keep a distance (stand-off distance), according to the technical specifications of the sensor model.	
2	Connect the Power-I/O cable to the socket (11) on the mounted sensor. **NOTE** Do not power on the sensor.	
3	Connect the Ethernet cable to the socket (10) on the mounted sensor.	
4	Connect the Ethernet cable to the host computer.	
5	Optional: Connect the encoder cable to the socket (9) of the sensor.	
6	If necessary, attach a strain relief device. When laying the cables, pay attention to compliance with the minimum bending radius.	
7	Connect the Power-I/O cable to a 24 V power supply.	
8	Apply the supply voltage.	
9	Check readiness for operation. **NOTE** • The Alive LED (1) indicates whether the sensor is supplied with supply voltage. • If the LED flashes, the sensor is supplied with suppy voltage and ready for operation.	

Step	Action	Schematic
10	Install the StarterKit Software to start capturing data from the sensor. **NOTE** See installation guide *Getting Started*.	

Alive LED-L1

The Alive LED (1) indicates the following operating states of the sensor:

Alive LED	Meaning
Green (flashing fast)	As soon as the supply voltage is applied.
Green (flashing slow)	Upon successful network connection.
Red (permanently lit)	In the event of an error.

Status LED-L2

LED	Meaning
Green	Physical Ethernet connection established.
Orange	2.5 V threshold used for Input 0/1/2/3 (otherwise 10 Volt threshold).
Red	Hardware reset active; LED flashes for 20 ms after sensor power on. If the red LED is permanently lit, the sensor encountered a serious error.

5 Get started

5.1 Connection Setup

General

After you have mounted and powered your ECCO 3D sensor successfully, it's time to establish a connection between the sensor and the host computer. Prior to this, please make sure that you have installed the latest version of the "StarterKit Software" on the host computer.

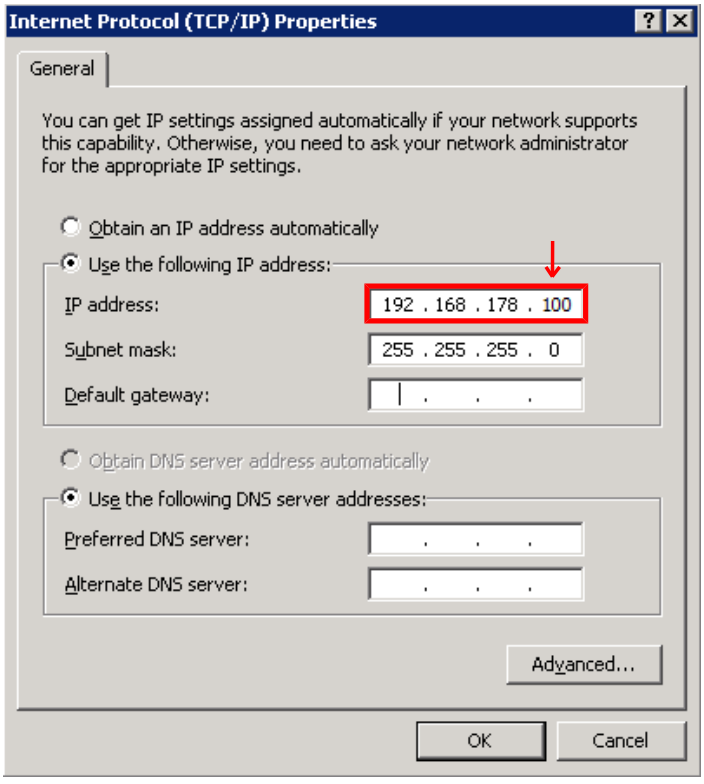
You can connect to the sensor using SmartRay Studio 3 or 4 (Studio 4 recommended) or 3rd party application softwares supported by SmartRay.

NOTICE

Make sure to configure the IP address of your computer network card to lie in the same range of the sensor's IP address.

IP address of the host computer

The last three numbers may not be the sensor IP-address (e.g. 200) or 0 (see arrow).


Internet Protocol (TCP/IP) Properties
General
You can get IP settings assigned automatically if your network supports this capability. Otherwise, you need to ask your network administrator for the appropriate IP settings.
Obtain an IP address automatically
Use the following IP address:
IP address:
192 . 168 . 178 . 100
Subnet mask:
255 . 255 . 255 . 0
Default gateway:
Obtain DNS server address automatically
Use the following DNS server addresses:
Preferred DNS server:
Alternate DNS server:
Advanced...
OK
Cancel

Factory default ‘IP address | Port number’

The sensors shipped by SmartRay are configured with the following standard IP address and port number:

- Default IP address: 192.168.178.200
- Port number: 40

Use the available connection manager to configure the IP address of the sensor.

NOTICE

For detailed information regarding the configuration of the IP address of the sensor, see the user manual of the used application software, e.g. Studio 4.

5.2 Capturing Data

General

After proper installation and connection, the sensor is ready for operation.

Information on the data (images, point clouds) provided by the sensor can be found in the following section.

Function

The 3D sensor generates 3D data of an object line by line, and therefore a relative movement between the sensor and/or the object is necessary to create the complete 3D model of the scanned object.

Data from SmartRay 3D sensors can be grouped into 2 parts:

Non-Calibrated Data

- Live Image (Setup & Debug)
- 3D-Profile
- Intensity
- Laser Line Thickness

Calibrated Data

- Point Cloud
- Z-map
- $\text{Intensity}_{\text{Z-Map}}$
- $\text{Laser Line Thickness}_{\text{Z-Map}}$

Coordinate types

SmartRay technology distinguishes between two different kinds of coordinate systems:

- Image coordinate
  non-calibrated coordinates in pixels
- World coordinate
  calibrated coordinates in millimeters

NOTICE

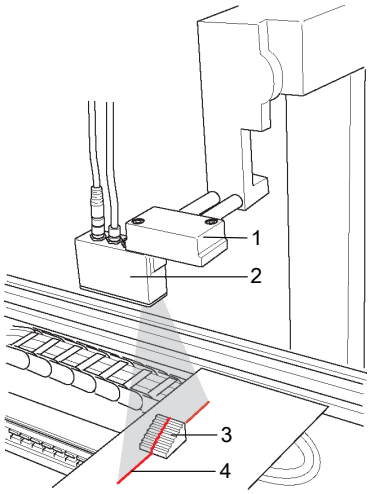
For more detailed information regarding the structure of the image data, please refer to the *SmartRay* API user manual.

5.3 Image types

Live Image

The Live Image enables to start the capture of a live video stream from the sensor with the configured sensor parameters (ROI / Exposure / Gain, etc.).

Designation	Description
General	The Live Image represents a normal video stream (i.e. 2D-images type in pixel). The Live Image is very helpful in setting up the sensor parameters and debugging to assist in capturing your 3D-data. **Note** Using the possibilities of your application software, you should setup the Live Image following these tips: ● not under-exposed, ● not over-exposed, ● optimum exposure: the laser line reflected from the object is thin and sharp.
Format/Bit depth	Image / 8, i.e. 8 bits/pixel (range 0 – 255)

Designation	Description
Live Image example	**Sensor setup**  1 Stand 2 3D sensor 3 Object 4 Laser line **Live Image**

Non-Calibrated 3D-image data types

Overview

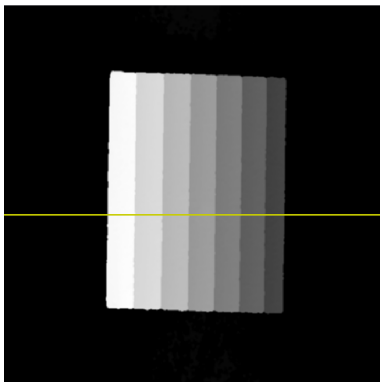
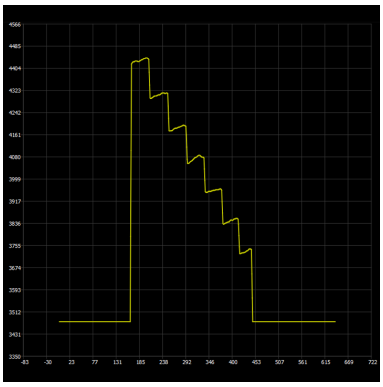
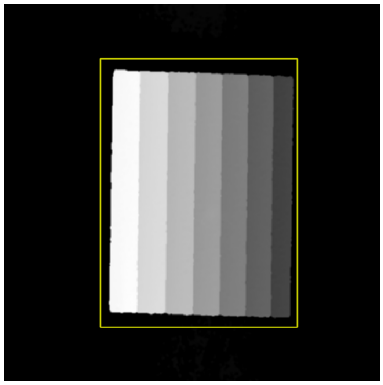
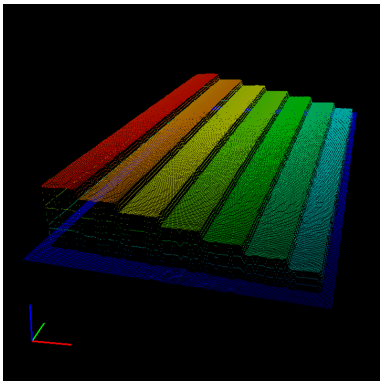
The sensor offers the following Non-Calibrated 3D-image formats (in pixel e.g. in image coordinate system):

- 3D-Profile
- Intensity
- Laser Line Thickness

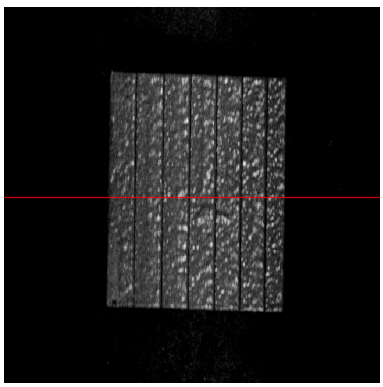
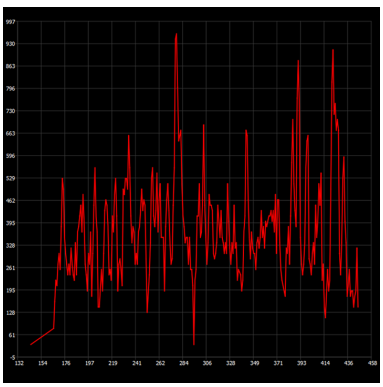
These image formats are called PIL (**P**rofile, **I**ntensity, **L**aserLineThickness).

3D-Profile

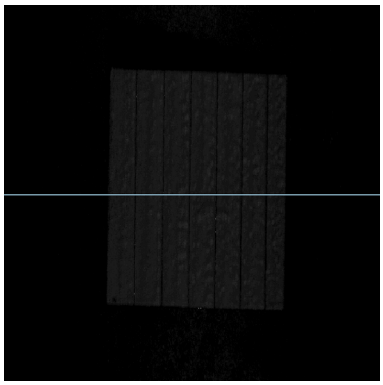
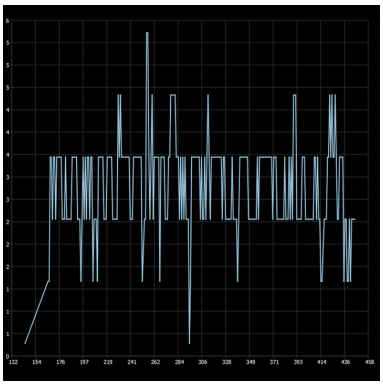
Designation	Description
General	The non-calibrated 3D-Profile image is an image, which represents for each pixel the height (Z-dimension) of the scanned object.
Format/Bit depth	14, i.e. 14 bits/pixel (range 0-16,383)

Designation	Description	
3D-Profile example	**3D-Profile Map**	**Graphic analysis**
		
	3D-Profile Map	**3D-Visualisation**
		

Intensity

Designation	Description	
General	The non-calibrated Intensity image is an image, which represents for each pixel the grey-sum of the scanned object.	
Format/Bit depth	14, i.e. 14 bits/pixel (range 0 – 16,383)	
Intensity example	**Intensity Map**	**Graphical analysis**
		

Laser Line Thickness

Designation	Description
General	The non-calibrated Laser Line Thickness image is an image, which represents for each pixel the thickness image of a laser line of the scanned object.
Format/Bit depth	6, i.e. 6 bits/pixel (range 0 – 63)
Laser Line Thickness example	**Laser Line Tickness Map**  **Graphical analysis** 

Calibrated 3D-image data types

Overview

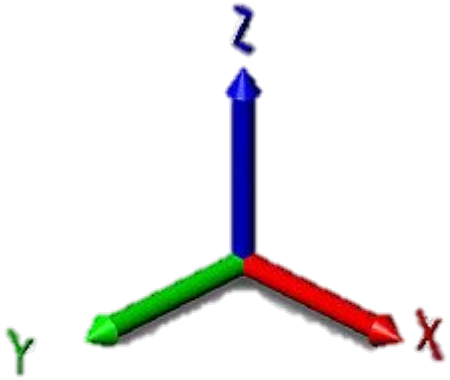
With the help of a calibration file, i.e. a look up table (LUT), that is unique for each and every sensor, the non-calibrated pixel coordinates (X_{Image}, Y_{Image}) are converted to calibrated coordinates (X_{World}, Y_{World}, Z_{World}).

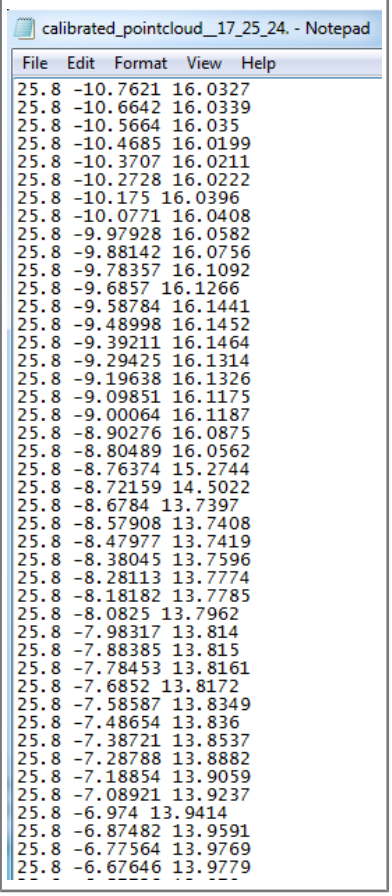
The sensor offers the following calibrated 3D-image formats (in world coordinates X_{World}, Y_{World}, Z_{World} with points in mm):

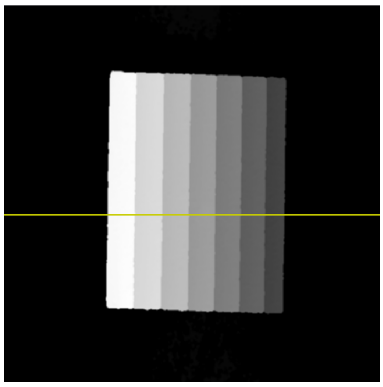
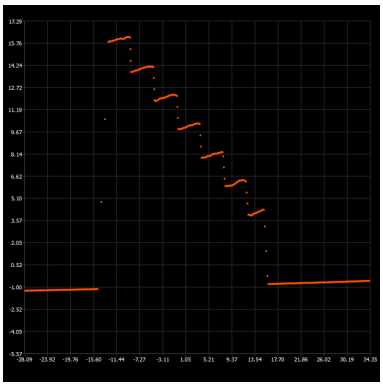
- Point Cloud
- Z-Map
- $Intensity_{Z\text{-}Map}$
- Laser Line $Thickness_{Z\text{-}Map}$

These image formats are called ZIL (**Z**-Map, **I**ntensity, **L**aserLineThickness)

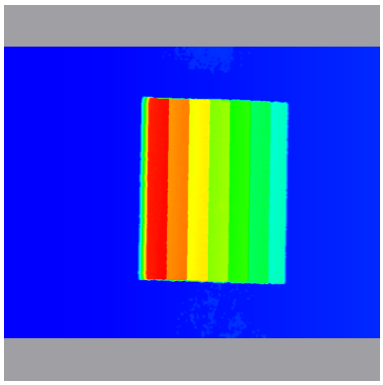
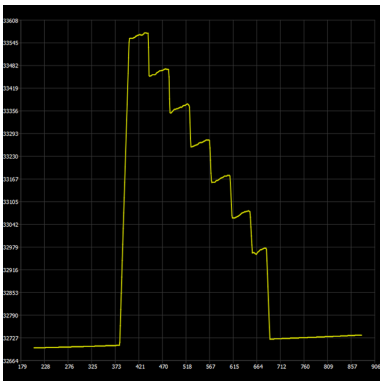
Point Cloud

Designation	Description
General	The Point Cloud is a calibrated 3D point cloud, which represents for each point the calibrated point cloud coordinates (X_{World}, Y_{World}, Z_{World}) of the scanned object. 
Format	The calibrated point cloud coordinates (X_{World}, Y_{World}, Z_{World}) are available in the following formats: • ASCII • CSV **NOTE** ASCII-separator: X_Y_Z (delimiter space separated) CSV-separator: X,Y,Z (comma-separated) or X;Y;Z (semi-colon-separated).

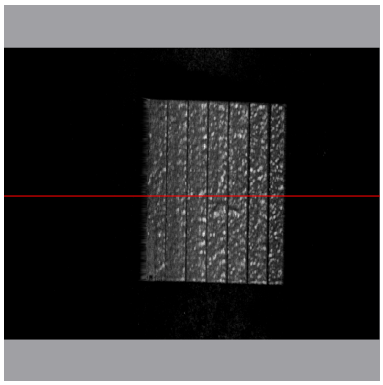
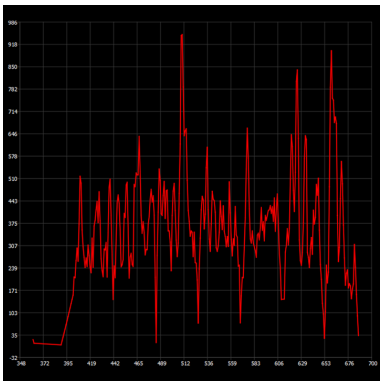


Designation	Description	
Point Cloud example	**3D-Profile Map**	**Point Cloud**
		

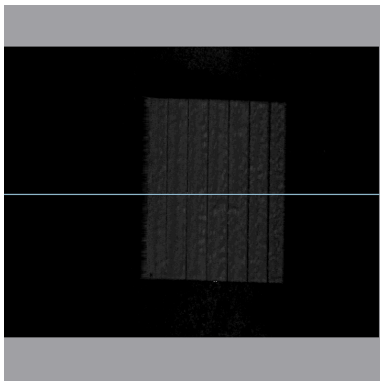
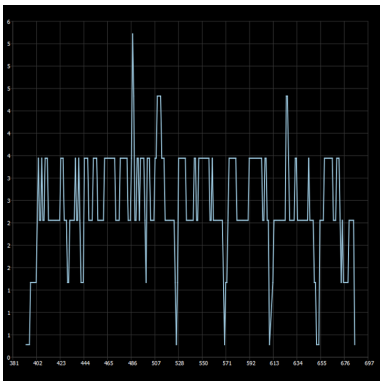
Z-Map

Designation	Description	
General	The Z-map is an image, which represents for each pixel the calibrated height (Z-dimension) of the scanned object in world coordinate system. **NOTE** The SmartRay API converts calibrated Point Cloud to a Z-map. For more information on to decode your Z-map pixels back to real world units, i.e. in millimeters, please refer to the illustration in the SmartRay API user manual, under the Chapter "Calibrated Data Control".	
Format/Bit depth	Image (Ex: PNG format) | 16-bits / pixel (range 0 – 65,535) **NOTE** A pixel with a value 32,768 (2^{15}) reflects a height value of 0 mm.	
Z-Map example	**Z-Map**	**Graphical analysis**
		

Intensity$_{Z\text{-}Map}$

Designation	Description
General	The Intensity$_{Z\text{-}Map}$ image is an image, in which each pixel represents the grey-sum of the laser line, additionally aligned to the 3D-Profile Z-map.
Format/Bit depth	16, i.e. 16 bits/pixel (range 0 – 65,535)
Intensity$_{Z\text{-}Map}$ example	**Intensity$_{Z\text{-}Map}$**  **Graphical analysis** 

Laser Line Thickness$_{Z\text{-}Map}$

Designation	Description
General	The Laser Line Thickness$_{Z\text{-}Map}$ image is an image, in which each pixel represents the thickness of the laser line, additionally aligned to the 3D-Profile Z-map.
Format/Bit depth	16, i.e. 16 bits/pixel (range 0 – 65,535)
Lase Line Thickness$_{Z\text{-}Map}$ example	**LaserLineThickness$_{Z\text{-}Map}$**  **Graphical analysis** 

5.4 Troubleshooting

What to do in the event of faults?

If the sensor is not working correctly, please contact Support at SmartRay GmbH.

For the address, see *Customer service/Support, page 46*.

Frequently asked questions (FAQ)

Q: How to update the firmware of the sensor?

A: The firmware of a sensor can be updated using the "firmware update file (*.fup)" that corresponds to the sensor. Please get in touch with your contact person at SmartRay to get latest updates on firmware releases!

Studio 3 and Studio 4 (version 4.1.0 onwards) have built-in functionality to update the firmware of the sensor. SmartRay API also provides functionality to update the firmware of the sensor.

	ATTENTION If one of the following situations occurs, it could render the sensor to not function anymore. In this case the sensor has to be sent back to SmartRay for repair. Therefore, when updating the firmware: • **Ensure** that the "firmware update file (*.fup)" corresponds to the sensor. • **Do not** power-off the sensor during firmware update. • **Do not** update an incompatible firmware version to the sensor.

Q: What do I do in case I updated the wrong firmware for the sensor?

A: In the event that a wrong firmware was uploaded to the sensor, you have to send the sensor back to SmartRay for repair, after filling the RMA form. Please get in touch with your SmartRay contact person if necessary.

Q: What do I do if I forgot the IP Address | Port Number of the sensor, after changing it?

A: SmartRay API with versions higher than 3.6.50 provide functionality to log the 'IP Address | Port Number', after it was modified successfully.

This functionality is enabled by default with API version higher than 3.6.50.

If you modified the 'IP Address | Port Number' of the sensor using Studio 3 or Studio 4 from StarterKit Software 3.6.50.0.0 or higher, the modified 'IP Address | Port Number' is saved in a log file called "sr_ip_modifier.log" - in the same path from where you run your application, i.e. for example, from where you run your Studio 3 or Studio 4 application.

Q: What do I do if I misplaced the calibration file (LUT)?

A: Please get in touch with your SmartRay contact person along with the "serial number" of the sensor.

Q: What do I do if I am not able to establish a connection to the sensor from my computer?

A: Make sure that :

- the sensor is powered-on,
- the "Alive signal (LED-L1)" is blinking on the sensor,
- there are no loose contacts on your Power-I/O or Ethernet connectors, or on the network switch, if used,
- the network card of your host computer is configured to lie within the same IP Address range as that of the sensor,
- not more than one software application is trying to connect to the sensor.

Recommended practices

CAUTION

Danger of injury from laser beams

Looking directly into the beam for a time period of more than 0.25 s or repeatedly looking into the laser beam of class 2/2M laser products can lead to eye injuries.

- If laser radiation of class 2 hits the eyes, consciously close your eyes and immediately turn away.

- Switch off the laser when not in use.
- Make sure that you do **not** mount the sensor in such a way that a direct or indirect laser reflection could harm you, or your co-workers.
- Always ensure that the sensor is transported based on ESD regulations.

6 Maintenance and repair

6.1 Maintenance

Cleaning deposits

Deposits (dirt, dust etc.) on the front glass of the sensor and the glass region from where the laser is omitted can affect the quality of the measurements. Therefore, regular cleaning is recommended.

NOTICE

Only clean the front glass of the sensor and the glass region from where the laser is omitted with a microfiber cloth and cleaning alcohol if necessary.

WARNING

Danger of injury from electricity.

Non-compliance with this instruction can cause injury.

- Before maintenance work, disconnect the sensor from the power supply.

6.2 Repair work

WARNING

Danger of injury from escaping laser radiation.

Unauthorized constructional modifications to the sensor can have an adverse effect on safety. SmartRay is solely responsible for repairs. Opening the housing will lead to loss of the guarantee.

- Never disassamble the sensors from SmartRay GmbH.

Defective sensor or defective sensor cable

In the event of a defect of the sensor or sensor cable, send in the defective product for replacement or repair.

NOTICE

Use the original packaging for sending back the sensor (ESD protection).

Dismantling the sensor or cables

Dismantle the sensor or defective cables in accordance with section *Dismantling, page 44*.

7 Decommissioning

7.1 Dismantling

General

Final decommissioning and disposal includes the complete uninstallation of the sensor.

Dismantling the sensor/cables

WARNING

Danger of injury from electricity.

Non-compliance with the following instruction can cause injury.

- Before maintenance work, disconnect the sensor from the power supply.

Proceed as follows to disassemble the sensor or defective cables:

Step	Action
1	Disconnect the sensor from the power supply.
2	Disconnect the connected cables from the sensor connectors.
3	Remove the strain relief device and dismantle the sensor from the holder (robot etc.).
4	Unplug the cables.
5	Package and send the sensor and/or cables to SmartRay.

WARNING

Danger of injury from incorrect handling.

Non-compliance with the following instruction can cause injury.

- Observe the relevant safety regulations and applicable accident prevention regulations.

7.2 Storage

Storing sensor components

Proceed as follows to store the sensor components:

Step	Action
1	If possible, store the sensor components in the original packaging in a dry location. If the original packaging is no longer available, store the sensor covered (dust protected) in a dry location.

Ambient conditions

Observe the following ambient conditions during storage:

Admissible storage temperature	-20 to +70 °C
Relative atmospheric humidity	40 to 70%, non-condensing

7.3 Disposal

Procedure

Proceed as follows to the dispose of the sensor and cables:

Step	Action
1	Dispose of the sensor and cables in an environmentally friendly manner in accordance with local provisions as well as the regulations and laws applicable at the time of disposal.
2	Alternatively, send the sensor and cables to: SmartRay GmbH Bürgermeister-Finsterwalder-Ring 12 82515 Wolfratshausen Germany

8 Customer service/Support

8.1 Customer service and support address

Return Material Authorization form

For repairs related and maintenance related requests send the sensor to the following address after filling out the RMA form.

Support address

SmartRay GmbH

Bürgermeister-Finsterwalder-Ring 12

82515 Wolfratshausen

Germany

Tel.:+49 8171 9683 400

Fax: +49 8171 9683 401

E-mail: info@smartray.de

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